(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 259 645 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
01.11.2017 Bulletin 2017/44

(21) Application number: **09816173.0**

(22) Date of filing: **24.09.2009**

(51) Int Cl.:
H04W 72/04 *(2009.01)* ***H04J 11/00*** *(2006.01)*
H04L 27/26 *(2006.01)*

(86) International application number:
PCT/JP2009/066555

(87) International publication number:
WO 2010/035758 (01.04.2010 Gazette 2010/13)

(54) **Cyclic prefix determination in OFDM communications**

Bestimmung des Zyklischen Präfixes in OFDM-Kommunikation

Détermination de préfixe cyclique dans les communications OFDM

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR

(30) Priority: **26.09.2008 JP 2008249295**

(43) Date of publication of application:
08.12.2010 Bulletin 2010/49

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- **"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Physical layer aspects for evolved Universal Terrestrial Radio Access (UTRA) (Release 7)", 3GPP STANDARD; 3GPP TR 25.814, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. V7.1.0, 1 September 2006 (2006-09-01), pages 1-132, XP050369161,**
- **"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 8)", 3GPP STANDARD; 3GPP TS 36.300, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. V8.6.0, 1 September 2008 (2008-09-01), pages 1-137, XP050377581,**

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Description

Technical Field

[0001] The present invention relates to a mobile station and a radio base station.

Background Art

[0002] In order to remove multipath interference, CP (Cyclic Prefix) is used in mobile communication systems based on the OFDM (Orthogonal Frequency Division Multiplexing) scheme and the DFT-Spread OFDM (Discrete Fourier Transform Spread OFDM) scheme, such as LTE (Long Term Evolution) scheme, WiFi (Wireless Fidelity) scheme, and WiMAX (Worldwide Interoperability for Microwave Access) scheme.

[0003] In such mobile communication system, CP with the same length is used for an uplink and a downlink based on an assumption that delay profiles of both links are substantially the same.

[0004] US 2007/002726 A1 relates to a system and method for adapting a cyclic prefix in an orthogonal frequency division multiplexing system. The document provides a method of adapting the length of the cyclic prefix to an expected delay spread in an OFDM cellular communication system. Here, it is specified that the document adapts the CP on a per-cell basis, and broadcasts the actual length of the CP to be utilized in each cell to UTs operating in the cell.

[0005] EP 1 650 920 A1 relates to an apparatus and method for cancelling inter-symbol interference in an OFDM system and shows methods of determining a cyclic prefix.

[0006] WO 2007/123340 A2 relates to a method and apparatus for inserting guard intervals in a mobile communication system and shows the use of a cyclic prefix having a length which is previously determined.

[0007] 3GPP TR25.814 V7.1.0 shows how a UE can acquire the CP length information regarding the subframe in which the SCH and/or BCH are transmitted.

Disclosure of the Invention

Problems to be Solved by the Invention

[0008] When a radio base station eNB transmits the same information via multiple antennas Ant#1 and Ant#2 as shown in Fig. 5(a) in the above-mentioned mobile communication system, either of the signals transmitted from the antennas Ant#1 and Ant#2 is observed as a delay wave by a mobile station UE as shown in Fig. 5(b) due to a difference between the cable lengths from the radio base station eNB to the antennas Ant#1, Ant#2.

[0009] Here, at the mobile station UE, the interference by the downlink signal transmitted from the antenna Ant#2 accounts for a large proportion of the interference and noise component in the downlink signal transmitted from the antenna Ant#1, while the interference by the downlink signal transmitted from the antenna Ant#1 accounts for a large proportion of the interference and noise component in the downlink signal transmitted from the antenna Ant#2. Thus, SINR can be increased by inserting "Extended CP" to the downlink signal.

[0010] On the other hand, also in the uplink, as shown in Figs. 6(a) and 6(b), uplink signals from a mobile station UE#1 received by respective antennas Ant#1 and Ant#2 are affected not only by the interference due to an uplink signal from a mobile station UE#2, but also by noise and/or other-cell interference, because transmission power of the uplink signal in each mobile station UE is limited. Thus, the effect achieved by inserting "Extended CP" to the uplink signal transmitted by each mobile station UE is not as significant as the effect achieved by inserting "Extended CP" to the downlink signal.

[0011] On the contrary, inserting "Extended CP" to the uplink, i.e., increasing the length of the CP causes an increase in the overhead and a reduction in the uplink communication capacity. Thus, this approach has a problem in that the negative effect is highly likely to be greater than the positive effect.

[0012] The present invention is made in view of the above mentioned problem, and it is an object of the present invention to provide a mobile station and a radio base station capable of flexibly changing lengths of CP used for the uplink and the downlink.

Solution to Problem

[0013] The object of the invention is achieved by the subject-matter of the independent claims. The dependent claims describe advantageous embodiments.

Brief Description of the Drawings

[0014]

[Fig. 1] Fig. 1 is an entire configuration diagram of a mobile communication system according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is a diagram showing an example of broadcast information transmitted by a radio base station according to the first embodiment of the present invention.

[Fig. 3] Fig. 3 is a functional block diagram of a mobile station according to the first embodiment of the present invention.

[Fig. 4] Fig. 4 is a diagram showing an example of CP used in the mobile station according to the first embodiment of the present invention.

[Fig. 5] Fig. 5 is a diagram for illustrating a problem of a mobile communication system of conventional LTE scheme.

[Fig. 6] Fig. 6 is another diagram for illustrating the problem of the mobile communication system of conventional LTE scheme.

Best Mode for Carrying out the Invention

(Mobile Communication System According to First Embodiment of the Present Invention)

[0015] Referring to Figs. 1 to 4, a mobile communication system according to a first embodiment of the present invention is described.

[0016] As shown in Fig. 1, the mobile communication system according to the present embodiment is a mobile communication system of the LTE scheme, and includes a radio base station eNB having antennas Ant#1 and Ant#2, and a mobile station UE.

[0017] Also, the mobile communication system according to the present embodiment is configured so that, as a radio access scheme, the OFDM scheme is applied to the downlink, and the "SC-FDMA (Single-Carrier Frequency Division Multiple Access) scheme" is applied to the uplink.

[0018] The OFDM scheme is a scheme that divides a specific frequency band into multiple narrow frequency bands (subcarriers) and transmits data over each frequency band. According to the OFDM scheme with such feature, high speed transmission can be achieved, and utilization efficiency of the frequency can be increased, by densely arranging subcarriers on a frequency axis without interfering with each other while allowing partial overlap between them.

[0019] Also, the SC-FDMA scheme is a transmission scheme that can achieve less interference between multiple mobile stations UE, by dividing a specific frequency band, and performing transmission using different frequency bands between multiple mobile stations UE. According to the SC-FDMA scheme, lower power consumption and larger coverage by the mobile station UE can be achieved, because the SC-FDMA scheme has a feature that fluctuation in transmission power is reduced.

[0020] According to the mobile communication system according to the present embodiment, in the uplink, an uplink data signal is transmitted via e.g., PUSCH (Physical Uplink Shared Channel), and an uplink control signal is transmitted via e.g., PUCCH (Physical Uplink Control Channel).

[0021] On the other hand, in the downlink, a synchronization signal is transmitted via e.g., SCH (Synchronization Channel), a downlink data signal is transmitted via e.g., PDSCH (Physical Downlink Shared Channel), and a downlink control signal is transmitted via e.g., PDCCH (Physical Downlink Control Channel).

[0022] Also, in the downlink, an MIB (Master Information Block) is configured to be transmitted as broadcast information in each cell via e.g., PBCH (Physical Broadcast Channel), and SIB (System Information Block) 1 to 11 are configured to be transmitted via e.g., PDSCH (see. Fig. 2).

[0023] Specifically, the MIB is configured to include physical parameters such as a cell bandwidth and transmission antenna identification information, and a system frame number (SFN), and is configured to be transmitted in a period of 40 ms.

[0024] Also, the SIB1 is configured to be mapped to SI (System Information) -1 and is configured to be transmitted in a period of 80 ms. In addition, the SIB1 is configured to include PLMN-ID, TAC, a cell ID, cell border information "value tag", and scheduling data of other SI, etc.

[0025] Also, the SIB2 to the SIB8 are configured to be mapped to any one of SI-x and transmitted. For such SIB2 to SIB4, a transmission period can be set. For example, the SIB2 is configured to include common channel information and shared channel information, the SIB3 is configured to include cell re-selection information, and the SIB4 to the SIB8 are configured to include information of adjacent cells in the same frequency, information of adjacent cells in different frequencies, and the like.

[0026] The radio base station eNB is configured to specify the length of the CP to be inserted in an uplink signal (e.g., uplink data signal, and/or uplink control signal) for the mobile station UE in a predetermined cell (a cell under the control of the radio base station eNB) by the above-mentioned broadcast information. For example, the radio base station eNB is configured to make such specification by using the MIB, the SIB1, the SIB2, etc.

[0027] Also, the radio base station eNB may be configured to specify, by dedicated control information (e.g., RRC Connection Reconfiguration), the length of the CP to be inserted in an uplink signal in the predetermined cell for the mobile station UE which performs a handover from another cell to the predetermined cell (cell under the control of the radio base station eNB).

[0028] Fig. 3 shows a portion of transmission configuration of an uplink transmission signal, out of the configuration of a mobile station UE according to the present embodiment. As shown in Fig. 3, the mobile station UE includes a DFT (Discrete Fourier Transformer) unit 11, a subcarrier mapping unit 12, an IFFT (Inversed Fast Fourier Transformer) unit 13, a CP adder unit 14, and a CP length determiner unit 15.

[0029] Coded data symbol is configured to be DFT-processed by DFT unit 11, and be inputted to the subcarrier mapping unit 12.

[0030] The subcarrier mapping unit 12 is configured to map an output signal (symbol) from the DFT unit 11 on continuous subcarriers.

[0031] The IFFT unit 13 is configured to perform IFFT processing on an output signal from the subcarrier mapping unit 12 (symbol y), and output a signal modulated by the DFT-Spread OFDM scheme to the CP adder unit 14.

[0032] The CP adder unit 14 is configured to generate an uplink signal by adding a CP to the input signal modulated by the DFT-Spread OFDM scheme, the CP having the length determined by the CP length determiner unit 15.

[0033] Now, as shown in Fig. 4, the CP to be inserted in the uplink signal is assumed to have two types: "Normal

CP" and "Extended CP" . The length T1 of "Extended CP" is longer than the length T2 of "Normal CP".

[0034] Both "Normal CP" and "Extended CP" are generated by copying a portion of an effective symbol. The CP may be called GI (Guard Interval).

[0035] The CP length determiner unit 15 is configured to determine the length of the CP to be inserted in the uplink signal.

[0036] The CP length determiner unit 15 is configured to be capable of setting the length of the CP to be inserted in the uplink signal (e.g., uplink data signal and/or uplink control signal) independently of the length of the CP inserted in the downlink signal (e.g., downlink data signal and/or downlink control signal).

[0037] The length of the CP to be inserted in the uplink signal, and the length of the CP inserted in the downlink signal (e.g. , downlink data signal and/or downlink control signal) may be set to the same length, or may be set to different lengths.

[0038] The mobile station UE can calculate the length of the CP inserted in the downlink signal, by using a synchronization signal received via the SCH.

[0039] Specifically, the CP length determiner unit 15 may be configured to set the length of the CP to be inserted in the uplink signal to the length specified in the broadcast information (e.g., the MIB, the SIB1, the SIB2, etc.) transmitted by the radio base station eNB.

[0040] Also, the CP length determiner unit 15 may be configured to set the length of the CP to be inserted in the uplink signal to the length specified in the dedicated control information (e.g., RRC Connection Reconfiguration) transmitted by the radio base station eNB at the time of a handover.

(Operations and Effects of Mobile Communication System according to First Embodiment of the Present Invention)

[0041] According to the mobile communication system of the present embodiment, the mobile station UE sets the length of the CP to be inserted in the uplink signal to the length specified in the broadcast information (e.g., MIB, SIB1, SIB2 etc.) transmitted by the radio base station eNB, so that it is possible to make the length of the CP applied in the uplink and the length of the CP applied in the downlink different.

[0042] Also, according to the mobile communication system of the present embodiment, the mobile station UE sets the length of the CP to be inserted in the uplink signal to the length specified in the individual control information (e.g., RRC Connection Reconfiguration) transmitted by the radio base station eNB, so that it is possible to make the length of the CP applied in the uplink and the length of the CP applied in the downlink different.

[0043] Note that operation of the above described mobile station UE and the radio base station eNB may be implemented by means of hardware, a software module executed by a processor, or a combination of both.

[0044] The software module may be provided in any type of storage medium such as an RAM (Random Access Memory), a flash memory, a ROM (Read Only Memory), an EPROM (Erasable Programmable ROM), an EEPROM (Electronically Erasable and Programmable ROM), a register, a hard disk, a removable disk, or a CD-ROM.

[0045] The storage medium is connected to the processor so that the processor can read and write information from and to the storage medium. Also, the storage medium may be integrated into the processor. Also, the storage medium and the processor may be provided in an ASIC. The ASIC may be provided in the mobile station UE and the radio base station eNB. Also, the storage medium and the processor may be provided in the mobile station UE and the radio base station eNB as a discrete component.

[0046] Hereinabove, the present invention has been described in detail using the above embodiment; however, it is apparent to those skilled in the art that the present invention is not limited to the embodiment described herein.

Claims

1. A mobile station (UE) comprising:

a cyclic prefix length determiner unit (15) configured to determine a length of a cyclic prefix to be inserted in an uplink signal; and
a cyclic prefix adder unit (14) configured to generate the uplink signal by adding a cyclic prefix to any one of an inputted signal modulated by DFT-Spread OFDM, Single Carrier FDMA, scheme and an inputted signal modulated by OFDM scheme, the cyclic prefix having the length determined by the cyclic prefix length determiner unit, wherein
the cyclic prefix length determiner unit (15) is configured to set the length of the cyclic prefix to be inserted in the uplink signal independently of a length of a cyclic prefix inserted in a downlink signal, and
the cyclic prefix length determiner unit (15) is configured to set the length of the cyclic prefix to be inserted in the uplink signal to a length specified in dedicated control information transmitted by a radio base station (eNB) at a time of a handover.

2. The mobile station (UE) according to claim 1, wherein
the cyclic prefix length determiner unit (15) is configured to set the length of the cyclic prefix to be inserted in the uplink signal to a length specified in broadcast information transmitted by a radio base station (eNB).

3. A radio base station (eNB) configured to receive an uplink signal from a mobile station (UE) in a predetermined cell, the uplink signal being generated by adding a cyclic prefix to any one of a signal modulated by DFT-Spread OFDM, Single Carrier FDMA, scheme and a signal modulated by OFDM scheme, wherein
the radio base station (eNB) is configured to specify a length of the cyclic prefix to be inserted in the uplink signal, for the mobile station which performs a handover from another cell to the predetermined cell, by dedicated control information.

Patentansprüche

1. Mobilstation (UE), umfassend:

eine Zyklisches-Präfix-Länge-Determinator-Einheit (15), die dazu ausgebildet ist, eine Länge eines zyklischen Präfixes, das in ein Uplink-Signal einzusetzen ist, zu determinieren; und
eine Zyklisches-Präfix-Addierer-Einheit (14), die dazu ausgebildet ist, durch Addieren eines zyklischen Präfixes zu einem von einem eingegebenen Signal, das durch ein DFT-Spreizung-OFDM-, Einzelträger-FDMA-, Schema moduliert ist, und einem eingegebenen Signal, das durch ein OFDM-Schema moduliert ist, das Uplink-Signal zu erzeugen, wobei das zyklische Präfix die durch die Zyklisches-Präfix-Länge-Determinator-Einheit determinierte Länge aufweist, wobei
die Zyklisches-Präfix-Länge-Determinator-Einheit (15) dazu ausgebildet ist, die Länge des zyklischen Präfixes, das in das Uplink-Signal einzusetzen ist, unabhängig von einer Länge eines zyklischen Präfixes, das in ein Downlink-Signal eingesetzt ist, festzulegen, und
die Zyklisches-Präfix-Länge-Determinator-Einheit (15) dazu ausgebildet ist, die Länge des zyklischen Präfixes, das in das Uplink-Signal einzusetzen ist, auf eine Länge festzulegen, die in einer dedizierten Steuerinformation spezifiziert ist, die zu einem Zeitpunkt einer Übergabe durch eine Funkbasisstation (eNB) übertragen wird.

2. Mobilstation (UE) nach Anspruch 1, wobei die Zyklisches-Präfix-Länge-Determinator-Einheit (15) dazu ausgebildet ist, die Länge des zyklischen Präfixes, das in das Uplink-Signal einzusetzen ist, auf eine Länge festzulegen, die in einer Rundsendeinformation spezifiziert ist, die durch eine Funkbasisstation (eNB) übertragen wird.

3. Funkbasisstation (eNB), die dazu ausgebildet ist, ein Uplink-Signal von einer Mobilstation (UE) in einer vorbestimmten Zelle zu empfangen, wobei das Uplink-Signal durch Addieren eines zyklischen Präfixes zu einem von einem Signal, das durch ein DFT-Spreizung-OFDM-, Einzelträger-FDMA-, Schema moduliert ist, und einem Signal, das durch ein OFDM-Schema moduliert ist, erzeugt wird, wobei
die Funkbasisstation (eNB) dazu ausgebildet ist, eine Länge des zyklischen Präfixes, das in das Uplink-Signal einzusetzen ist, durch eine dedizierte Steuerinformation für die Mobilstation, die eine Übergabe von einer anderen Zelle zu der vorbestimmten Zelle durchführt, zu spezifizieren.

Revendications

1. Station mobile (UE) comprenant :

une unité de détermination de longueur de préfixe cyclique (15) configurée pour déterminer une longueur d'un préfixe cyclique à insérer dans un signal montant ; et
une unité d'addition de préfixe cyclique (14) configurée pour générer le signal montant en ajoutant un préfixe cyclique à l'un quelconque parmi un signal entré modulé par un schéma OFDM à étalement DFT, un schéma FDMA à une seule porteuse et un signal entré modulé par un schéma OFDM, le préfixe cyclique possédant la longueur déterminée par l'unité de détermination de longueur de préfixe cyclique, dans laquelle
l'unité de détermination de longueur de préfixe cyclique (15) est configurée pour régler la longueur du préfixe cyclique à insérer dans le signal montant indépendamment d'une longueur d'un préfixe cyclique inséré dans un signal descendant;et
l'unité de détermination de longueur de préfixe cyclique (15) est configurée pour régler la longueur du préfixe cyclique à insérer dans le signal montant à une longueur spécifiée dans des informations de commande dédiées transmises par une station de base radio (eNB) au moment d'un transfert.

2. Station mobile (UE) selon la revendication 1, dans laquelle l'unité de détermination de longueur de préfixe cyclique (15) est configurée pour régler la longueur du préfixe cyclique à insérer dans le signal montant à une longueur spécifiée dans des informations de diffusion transmises par une station de base radio (eNB).

3. Station de base radio (eNB) configurée pour recevoir un signal montant à partir d'une station mobile (UE) dans une cellule prédéterminée, le signal montant étant généré en ajoutant un préfixe cyclique à l'un quelconque parmi un signal entré modulé par un schéma OFDM à étalement DFT, un schéma FDMA

à une seule porteuse et un signal modulé par un schéma OFDM, dans laquelle
la station de base radio (eNB) est configurée pour spécifier une longueur du préfixe cyclique à insérer dans le signal montant pour la station mobile qui met en oeuvre un transfert à partir d'une autre cellule jusqu'à la cellule prédéterminée, via des informations de commande dédiées.

FIG. 1

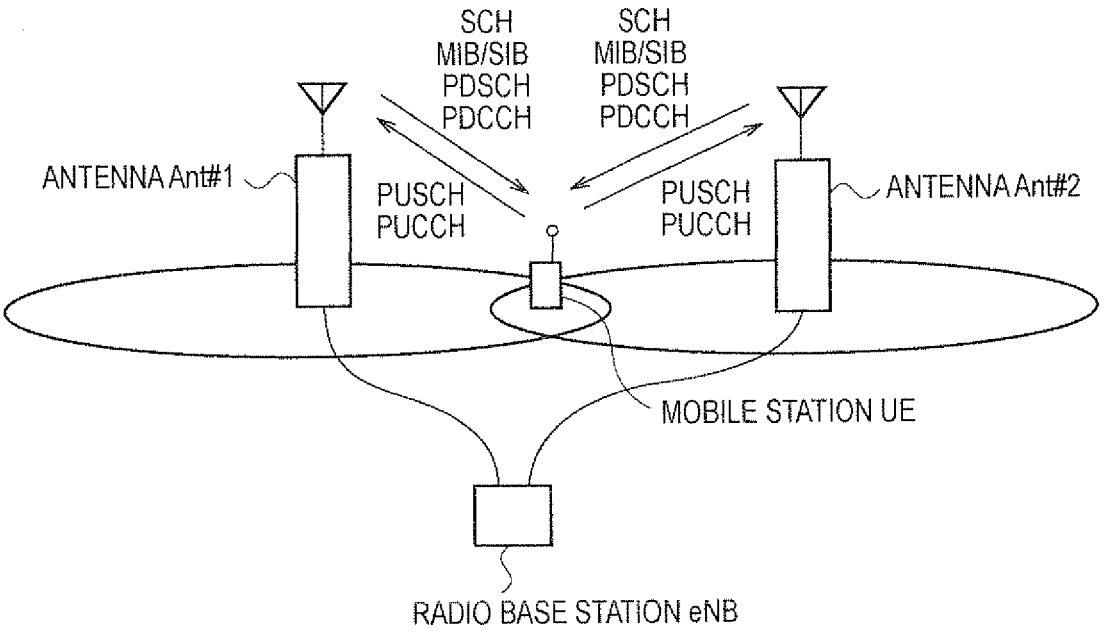

SCH
MIB/SIB
PDSCH
PDCCH
SCH
MIB/SIB
PDSCH
PDCCH
ANTENNA Ant#1
PUSCH
PUCCH
PUSCH
PUCCH
ANTENNA Ant#2
MOBILE STATION UE
RADIO BASE STATION eNB

FIG. 2

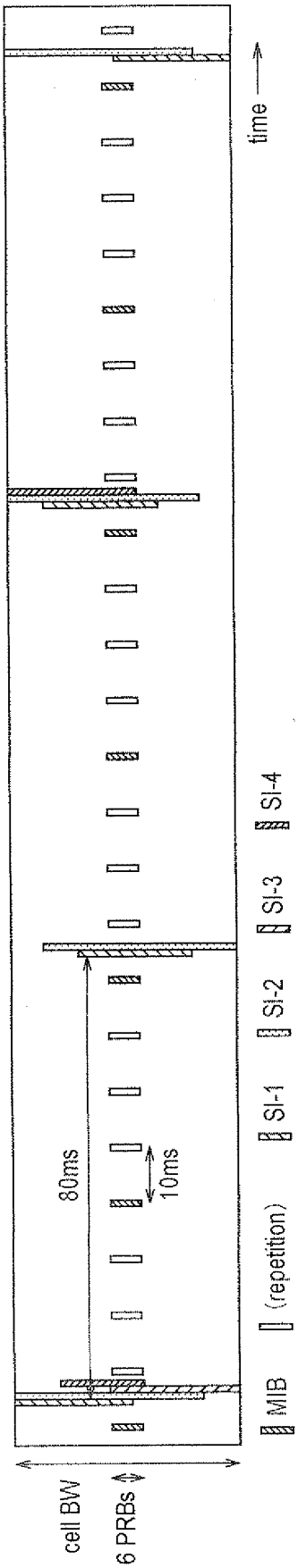


FIG. 3

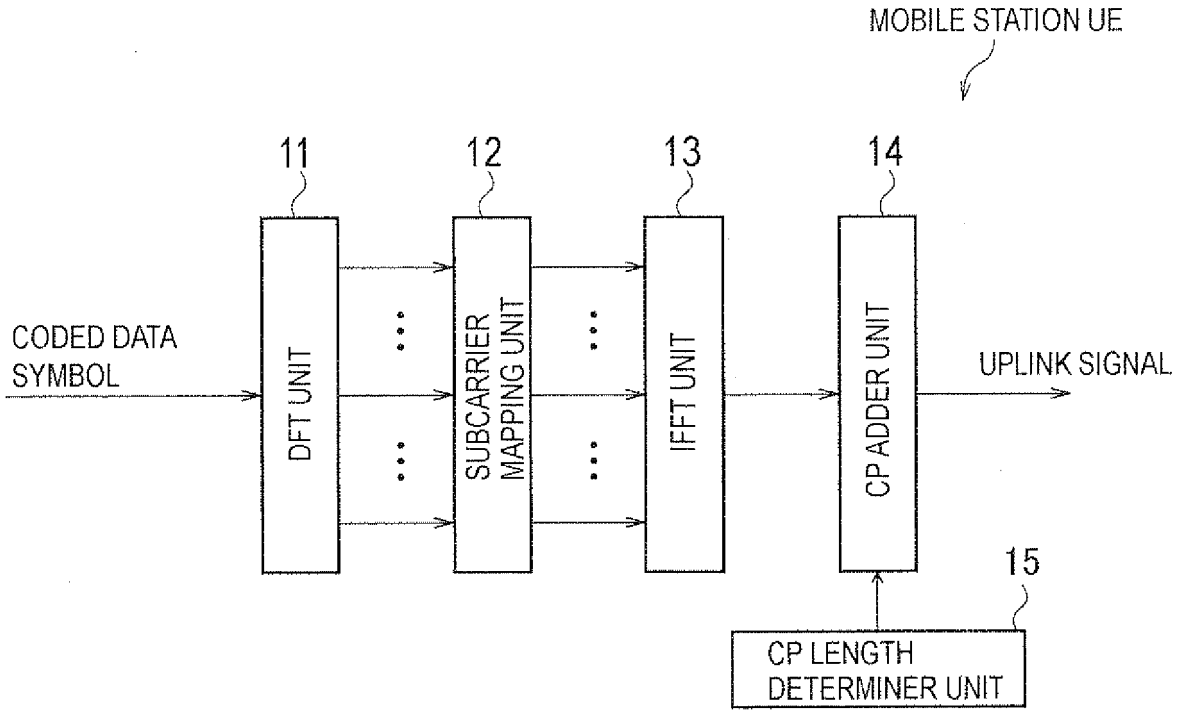

MOBILE STATION UE
11
12
13
14
CODED DATA SYMBOL
DFT UNIT
SUBCARRIER MAPPING UNIT
IFFT UNIT
CP ADDER UNIT
UPLINK SIGNAL
15
CP LENGTH DETERMINER UNIT

FIG. 4

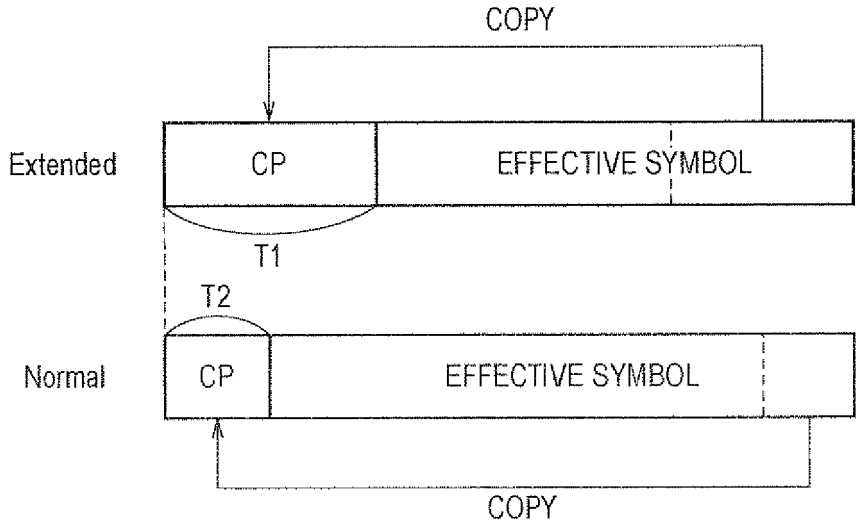

COPY
Extended
CP
EFFECTIVE SYMBOL
T1
T2
Normal
CP
EFFECTIVE SYMBOL
COPY

FIG. 5(a)

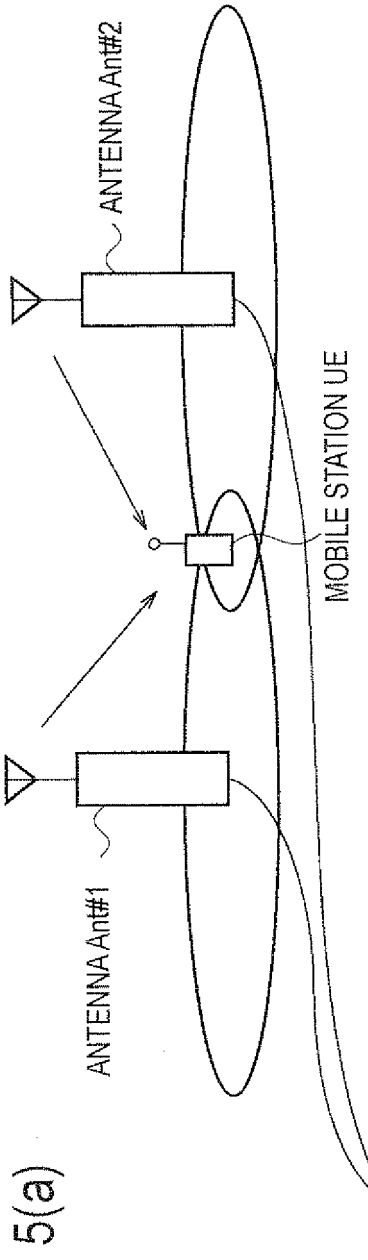

ANTENNA Ant#2
ANTENNA Ant#1
MOBILE STATION UE
RADIO BASE STATION eNB

FIG. 5(b)

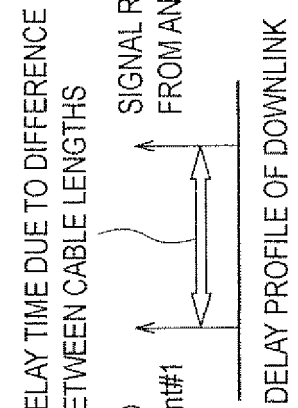

DELAY TIME DUE TO DIFFERENCE BETWEEN CABLE LENGTHS
SIGNAL RECEIVED FROM ANTENNA Ant#1
SIGNAL RECEIVED FROM ANTENNA Ant#2
DELAY PROFILE OF DOWNLINK

FIG. 6(a)

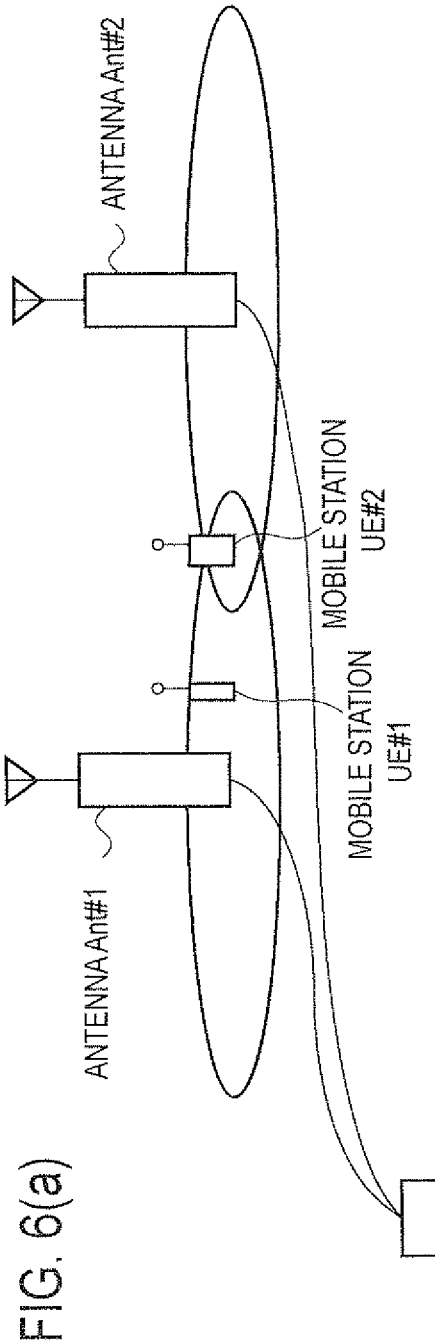
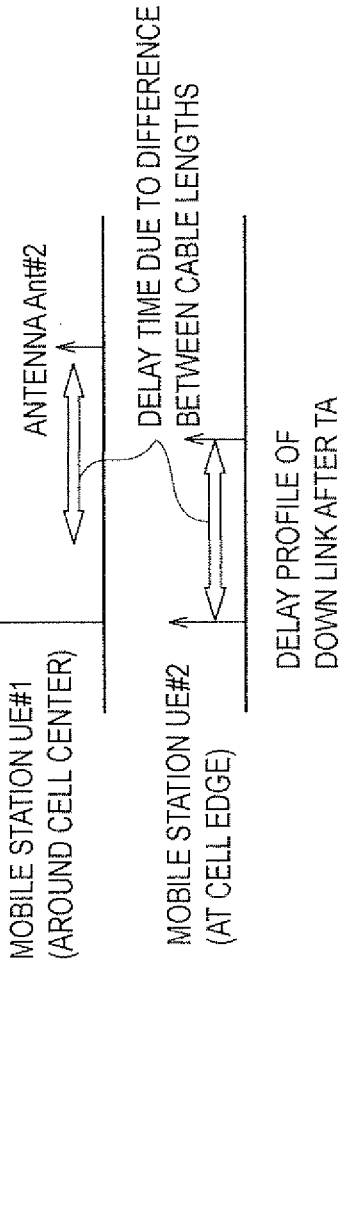

ANTENNA Ant#2
ANTENNA Ant#1
MOBILE STATION UE#2
MOBILE STATION UE#1
RADIO BASE STATION eNB

FIG. 6(b)


ANTENNA Ant#1
ANTENNA Ant#2
DELAY TIME DUE TO DIFFERENCE BETWEEN CABLE LENGTHS
MOBILE STATION UE#1 (AROUND CELL CENTER)
MOBILE STATION UE#2 (AT CELL EDGE)
DELAY PROFILE OF DOWN LINK AFTER TA

REFERENCES CITED IN THE DESCRIPTION

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